Surface combatants, always an important element of naval forces, are now the subject of especially intense interest in the Although major surface combatants-battleships and cruisers--were the centerpiece of fleet battle forces in the years preceding World War II, ships of this category have declined in relative importance since that time, with dominance passing to aircraft carriers and nuclear submarines. Since World War II. surface combatants have been used largely in escort and support roles--vital functions to be sure, but clearly a step removed from their former glory. Now the surface combatant appears to be in the path of several converging technological trends that could produce dramatic new capabilities -- a development that would place the surface combatant firmly back in the front rank of naval strike forces.

Cruise missiles, ship-based helicopters, new antisubmarine sensors, and dramatic improvements in anti-air warfare systems are among the factors that have contributed to this resurgence. But technology cuts the other way as well; these and other developments in the hands of potential adversaries can be expected to produce new or more dangerous threats to future U.S. surface combatants. Providing for well-considered programs for building surface combatant ships and for a vigorous research and development program to support those ships will be an important undertaking for the Congress in fulfilling its constitutional responsibility to "provide and maintain a Navy."

Given the high procurement cost of modern warships, a sustained program to replace and improve the current surface combatant force will be a very large and continuing budget item. Investment costs alone for each of the program alternatives considered in this report will total approximately \$33 billion over the next 10 years. 1/2 In addition to investment costs, funding must be provided for continuing research and development on new surface combatant construction and fleet upgrade programs.

^{1/} All costs in this paper, unless otherwise specified, are in constant fiscal year 1982 dollars.

To these expenses must be added the operating costs for the ships, which, over their service life, can total as much or more than their investment cost.

In its deliberations on this issue, the Congress will be considering several related questions:

- o How large a surface combatant force will the Navy have in the 1990s, given the number of new ships already authorized and the ships now in the fleet that will not have reached the end of their service lives?
- o How might recent technological developments affect the likely role of future surface combatants?
- o Given these technological developments, and alternative views of naval strategy, what mix of surface combatants might be considered within whatever budget level the Congress selects?

These questions are the focus of this paper.

Chapter II assesses the current naval surface combatant force in terms of its size and capabilities, and examines how force levels are projected to change in the future. These future force levels are then compared to the Navy's current statement of its requirements. The chapter also discusses several important modernization programs that have been proposed by the Navy to upgrade current surface combatants—programs that will affect fleet capabilities more immediately.

Chapter III addresses the contribution of surface combatants to overall naval force effectiveness and assesses their likely role in the future. It considers several technological developments that could lead to significant improvements in surface combatant capabilities.

Chapter IV describes four alternative shipbuilding programs for the period 1986-1995 that respond to differing projections of future surface combatant requirements.

Force level requirements presented in the Navy's 1980 testimony, which served as the basis of the most recent shipbuilding decisions by the Congress, are used in this report. Some implications of more ambitious force level goals, just proposed by the new Administration, are discussed in Chapter IV.

NUMERICAL TRENDS

A widely used and unquestionably significant indicator of naval strength is the number of ships available in the fleet. Despite the many caveats that must attend simple numerical comparisons—caveats as to individual ship capability, training and readiness levels, tactics, mission requirements, etc.—such comparisons can be a useful first—order indicator of force trends.

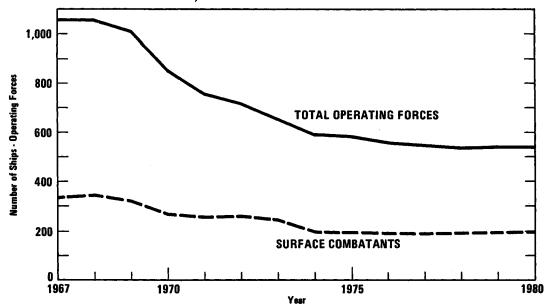
Current Force Levels

The number of ships in the U.S. Navy declined sharply during the six-year period 1968-1974, dropping from 1,055 to 587 units. The surface combatant segment followed a similar trend, declining from 339 units in 1968 to 198 units in 1974. This decline resulted in large part from the retirement of many 25- to 30-year-old World War II-era ships that had reached the end of their service lives. Since 1974, force levels have remained fairly constant, with total ship operating forces (as of September 30, 1980) at 538 units, of which 193 are surface combatants. These trends are shown in Figure 1.

Oceangoing surface combatants are usually designated as cruisers, destroyers, or frigates depending upon their size and Although cruisers of the World War II era were capabilities. distinctly different in design from destroyers (cruisers carried extensive armor and substantially heavier armament), today's surface combatants can be viewed as lineal descendants of the destroyer type, scaled up or down in size to accommodate their weapons suite (the aggregate collection of weapons and sensor systems) and ship performance requirements. Cruisers are the largest and most capable of the three types; destroyers are usually smaller and less capable; and frigates are the smallest and least capable ships. Classifications are often somewhat arbitrary, however, since a warship's effectiveness can vary more with its age than with its size. 1/

 $[\]underline{1}/$ Before 1975, the term "frigate" was used to designate a ship larger than a destroyer but smaller than a cruiser. In 1975,

Figure 1.
U.S. Naval Force Level Trends: Total Operating Forces and Surface Combatants, 1967-1980

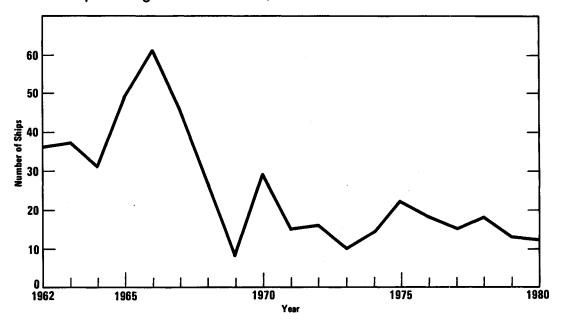


New Authorizations

Throughout most of the 1960s, naval ship production proceeded at a substantially higher pace than the level that has prevailed in recent years. Toward the end of the decade, however, steadily shrinking shipbuilding budgets, together with increasing shipbuilding costs, resulted in a sharp decline in new ship authorizations. This trend is illustrated in Figure 2, which shows the number of naval ships authorized for construction each year over the fiscal year 1962-1980 period. Throughout the 1970s and

frigates (DLG/DLGN) were reclassified as cruisers (CG/CGN), and the term "frigate" (FF/FFG) was applied to smaller ships that had previously been designated as "ocean escorts" (DE/DEG). In 1979, a new guided missile destroyer class, DDG-47, was administratively designated as a cruiser, CG-47, with the jusification that the cruiser designation was more appropriate to its capabilities.

Figure 2. Naval Shipbuilding Authorizations, 1962-1980



into the 1980s, new ship authorizations have remained substantially below the levels of the 1960s. In the 1990s, ships built in the high production period of the 1960s will reach 30 years of age and almost certainly will be retired. result in a substantial reduction in the size of the U.S. fleet if new ship authorizations continue at the same levels that have prevailed over the past decade. The drop is illustrated for the case of major surface combatants, often called "battle group surface combatants," by Figure 3, which plots force levels to the year 2000 given existing units, presently anticipated retirements, and currently authorized new construction. Approximately 65 surface combatants must be delivered in the 10-year period 1987-1997 just to maintain current force levels. That represents an average of 6.5 new surface combatants per year, significantly higher than the average of 3.3 new cruisers/destroyers authorized each year during the past decade.

Frigates, which are smaller surface combatants not classed by the Navy as battle group units, are intended for use in lower-threat missions. Frigates perform a variety of vital naval tasks—such as escort of convoys and replenishment ships, and support of amphibious groups—where it is important to have sufficient numbers of ships available. Because of active building programs in the late 1960s and into the 1980s, frigate force levels will remain relatively high with respect to the current level through the 1990s (see Figure 4).

Force Level Objectives

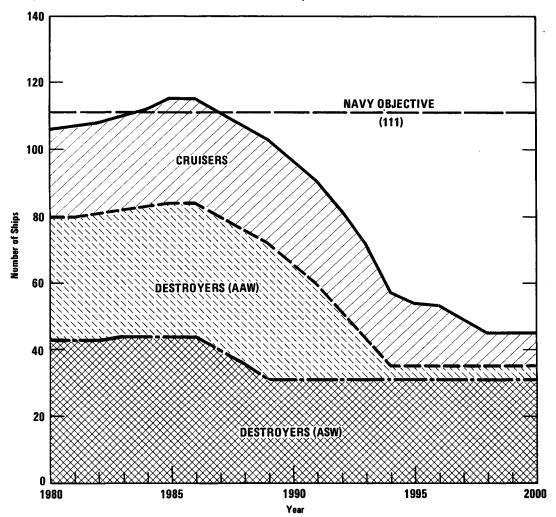
The dashed lines labeled "objective" in Figures 3 and 4 represent Navy force level objectives presented to the Congress in testimony in February 1980. The Navy has been careful to characterize these as only "minimum requirements." In the case of frigates, for example, the Navy stressed that, although anticipated force levels would exceed the stated objective, even more ships of that kind would undoubtedly be needed in a general war. 2/

The force level objectives presented by the Navy suggest that the most acute need for surface combatant units in the 1990s will be for battle group ships (see Figure 3). Although the projected decline from current force levels will not begin until the early 1990s, planning and funding for a program to replace ships scheduled for retirement should begin now, given the long lead time required to design and build modern warships and the combat system components they carry.

The Navy has recently initiated design studies for a new surface combatant, designated "DDGX," whose construction would begin in the mid-1980s. The Navy intends this ship to be a "battle group" combatant with a highly capable anti-air warfare (AAW) system and an antisubmarine warfare (ASW) screening capability using active sonar. Initial Navy plans called for procurement of about 50 of these ships, making the DDGX the major new surface combatant procurement item through the remainder of the century.

<u>2</u>/ Testimony of Vice Admiral James H. Doyle, Deputy Chief of Naval Operations for Surface Warfare, in <u>Military Posture and H.R. 6495</u>, Hearings before the Subcommittee on Seapower and Strategic and Critical Materials, House Committee on Armed Services, 96:2 (February and March 1980), Part 3, p. 91.

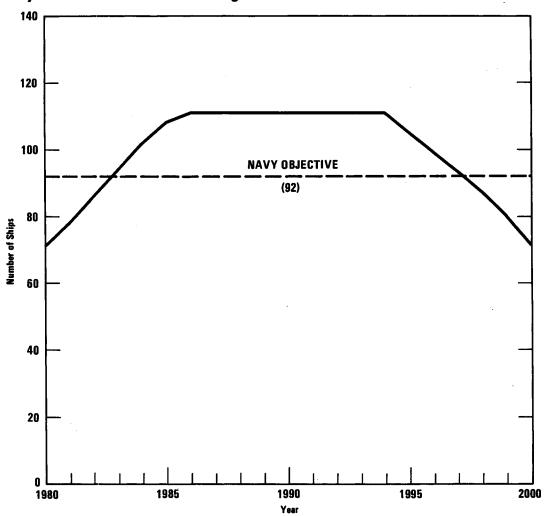
Figure 3. Projected Force Levels for Battle Group Surface Combatants



Note: Includes authorizations through fiscal year 1981. Objective of 111 was specified to the Congress in Navy testimony of February 1980. Testimony given to the Congress in March 1981 suggested a new, higher level of 137.

Figure 4.

Projected Force Levels for Frigates



Note: Includes authorizations through fiscal year 1981. Objective of 92 was specified to the Congress in Navy testimony of February 1980. Testimony given to the Congress in March 1981 suggested a new, higher level of 101.

THE NAVY'S PROPOSED SURFACE COMBATANT REQUIREMENTS

The Navy presently intends that its major offensive striking forces in a future war be carrier battle groups. At a procurement cost of more than \$16 billion, a carrier battle group represents a very large investment in ship construction. The Navy believes that sufficient forces should be available to maintain at least six carrier battle groups, each containing two aircraft carriers, three CG-47-class AEGIS ships, and nine other surface combatants. Carrier battle group requirements, therefore, generate a need for 72 surface combatants.

The Navy also sees a role for naval combat groups that do not contain carriers. These units, called surface action groups (SAGs), would undertake less demanding missions than carrier battle groups. A typical SAG might be composed of a CG-47-class cruiser and three other surface combatants. The Navy believes sufficient forces should be maintained to support at least three SAGs, which would require a total of 12 surface combatants.

The above offensively oriented groups should, in the Navy's view, be composed of higher-capability battle group surface combatants. For other tasks, the Navy would use the lower-capability frigates as well. Such tasks include support of amphibious operations, which would require 17 surface combatants, and underway replenishment group protection, which would require another 32 units.

Finally, convoy escort requirements must be considered. Force level requirements for this task are highly sensitive to the number of convoys assumed and to the contribution of U.S. allies to the convoy escort forces. Based on its assumptions as to convoy requirements and the level of allied support, the Navy believes that convoy support will require about 70 U.S. surface combatants. 3/

^{3/} Convoy escort requirements vary considerably depending upon the scenario. A recent CBO study found that escort requirements for the North Atlantic could range between 59 and 273 units, depending upon the assumptions made. Allowing for probable diversion of allied ships to other tasks, U.S. allies could be expected to provide only about 56 convoy escorts, leaving a requirement for as many as 217 escorts to be supplied by the United States or by additional allied

These force requirements for surface combatants are summarized in Table 1.

The force requirement rationale traced above is a commendable attempt by the Navy to construct a logical and coherent basis for force planning from which future shipbuilding requirements can be derived. Like any such plan, it rests upon assumptions about the future whose validity ultimately can be determined only by future events. The Navy does not characterize these as any more than minimum requirements. 4/ Actual conditions in some future war could, of course, generate a requirement for a different kind of Navy in terms of numbers of ships, mix of ships, or both. Chapter IV will examine in more detail how changes in requirements might affect the number and mix of surface combatants desired for the Navy.

QUALITATIVE ASPECTS

The numerical assessments made in the previous section are only one measure of naval strength and should not be considered in isolation from the capabilities of the ships counted. Clearly, not only must there be enough ships, but the ships available must be capable of performing their missions. 5/

Periodic modernization of the combat system capabilities of existing warships is a subject which, although it generally receives less attention than is accorded new construction programs, is of potentially equal or greater importance to overall force

construction. See Congressional Budget Office, Shaping the General Purpose Navy of the Eighties: Issues for Fiscal Years 1981-1985 (January 1980), pp. 56-58.

^{4/} One consideration not explicitly included in Table 1 and in the testimony from which it is derived is a factor to account for ship overhauls. Since at any given time some portion (typically about 15 percent) of the Navy's ships is undergoing overhaul, all of the forces in Table 1 would not be available at any one time unless the total fleet was about 15 percent larger than the number shown.

^{5/} A discussion of current surface combatant ship types and their capabilities is contained in Appendix A.

TABLE 1. BREAKDOWN OF THE NAVY'S SURFACE COMBATANT FORCE LEVEL OBJECTIVE (203 SHIPS)

Mission	Number of Ships Required						
Requirements	CGN	CG-47	DDG X	DD-993	DD-963	FF/FFG	
Six Two-Carrier						···	
Battle Groups							
3 CG-47s		18					
5 DDG X/CGNs	6		24		-		
4 DD-963s					24		
Three Surface							
Action Groups							
1 CG-47		3		•	-		
3 DDG Xs			9				
Amphibious							
Force <u>a</u> /							
8 DDG Xs			8		•••		
4 DD-993s				4	****		
5 FFG/FFs					****	5	
Seven							
Convoys							
1 DD-963					7		
9 FFG/FFs						63	
Eight Underway							
Replenishment							
Groups							
1 DDG X			8				
3 FFG/FFs						24	
Total	6	21	49	4	31	92	

SOURCE: Testimony of Vice Admiral James H. Doyle, USN, Deputy Chief of Naval Operations for Surface Warfare, in Military Posture and H.R. 6495, Hearings before the Subcommittee on Seapower and Strategic and Critical Materials, House Committee on Armed Services, 96:2 (February and March 1980), Part 3, pp. 87-88.

a/ Sufficient to support 1.15 Marine Amphibious Force (MAF).

effectiveness. Although the hull and machinery of a ship can usually perform adequately for 30 years, or even longer if necessary, combat system effectiveness typically declines at a much faster pace; a combat system can become outmoded in 10 years or less. If the modernization of older ships is neglected, numerical assessments of naval forces can be misleading. Naval power is a function not only of fleet size but also of the ability of the ships that make up the fleet to perform their missions in a combat environment. New weapons systems can be introduced into the fleet by building new ships, of course, but often fleet capabilities can be upgraded much more rapidly and at lower cost by "backfitting" new weapons systems onto existing ships.

An example of such a modernization program of particular importance to existing cruisers and destroyers is AAW system modernization. The AAW missile systems carried by most current guided missile cruisers and destroyers were designed before the cruise missile became a prime AAW concern and thus are not adequate for the current threat. To address this problem, the Navy has developed several backfit programs to upgrade the capabilities of its older guided missile ships. Three such programs are:

- o CG/SM-2 Upgrade;
- o New Threat Upgrade (NTU); and
- o DDG-2 Class Upgrade.

The CG/SM-2 Upgrade will provide the guided missile ships with a greatly expanded engagement envelope (that is, an increased intercept range and altitude capability) and a fourfold increase in firepower (number of targets engaged per unit of time). The NTU program makes these range and firepower gains sustainable in an electronic countermeasures (ECM) environment. The DDG-2 Upgrade will improve the reliability of the DDG-2-class destroyers. 6/

Given the high cost and resulting slow pace of the CG-47 construction program, these missile ship modernization programs are perhaps the only way to introduce substantial numbers of

^{6/} Appendix B provides a more detailed discussion of these three modernization programs.

upgraded AAW systems into the fleet during the the 1980s. The presently deferred CG/SM-2 Upgrade for the DDG-37 class alone would put 10 ships at sea with a modern, extended-range AAW capability at less than one-tenth the cost of a single CG-47.

RECAPITULATION: IMPENDING BLOCK OBSOLESCENCE FOR BATTLE GROUP SURFACE COMBATANTS IN THE 1990s

The picture that emerges from the above discussion is one of a Navy diminished in size from its former levels but now stabilizing at a level of just under 550 ships. The age of the ships presently in the fleet, however, portends another sharp drop in force level in the 1990s unless future ship procurement rates are increased from those prevailing over the past decade.

Existing surface combatant force levels are presently near the Navy's minimum objectives. Frigate force levels will continue to rise over the next few years as new ships now authorized for construction enter the fleet. Cruiser/destroyer, or "battle group," force levels are rising much more slowly, however, and will fall off abruptly in the 1990s. Compounding this is the fact that ships scheduled for retirement in the 1990s are now entering their third decade of service and in many cases already have obsolescent combat capabilities.

The question that arises is what, if anything, should be done about this? Will surface combatants continue to serve a useful function in modern warfare? Is that function sufficiently important to justify the substantial investment that will be required to replace aging units? This issue will be addressed in the next chapter.

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CHAPTER III. ROLE OF THE SURFACE COMBATANT IN NAVAL WARFARE: RENAISSANCE THROUGH TECHNOLOGY

Surface combatants, perhaps more than any other active naval weapons system, form a link with the Navy's past. Unlike aircraft carriers and submarines, which are quintessentially 20th century creations, surface combatants are the direct descendants of an unbroken line of fighting ships stretching back in time to the earliest sea battles. As such, they are the inheritors not only of centuries of naval tradition but also of centuries of evolutionary development in warship design. A question for current naval planners, and for the Congress, is whether they are more than this. Are present-day surface combatants merely the vestigial remnant of a long tradition, or are they still a vital component of naval forces whose place remains secure in logic as well as in tradition?

SURFACE COMBATANTS IN THE 20TH CENTURY: GRANDEUR AND DECLINE

Until World War II, the surface combatant was the centerpiece of naval forces. Dramatic improvements were made in the late 19th century, when the sail-driven wooden ships that had existed for centuries were replaced by new steam-propelled steel warships Those steel ships evolved into a mounting large rifled guns. variety of forms, dominated by huge, heavily armored battleships that carried enormous guns capable of delivering several tons of armor-piercing shells in a single broadside on a target 20 miles away. This era also saw the development of the big-gun cruisers, which were somewhat smaller, less heavily armored, and carried smaller guns than battleships but were still possessed of formi-At the low end of the spectrum was the desdable firepower. troyer, small and fast, carrying little or no armor, and armed with torpedoes and relatively small guns. These ships could operate in company to form a battle fleet, or in smaller groups or independently for patrol and presence missions. In their heyday, they were the essence of naval power.

Early in the 20th century, as the surface combatants were reaching the peak of their power and majesty, the Navy began to experiment with two new vehicles, the airplane and the submarine.

By the eve of World War II, aircraft and submarines had become firmly established in the spectrum of naval weapons; by the end of that war, both had decisively proven their capabilities, and the aircraft carrier and the submarine displaced surface combatants at center stage in the fleet.

The years following World War II saw continued dramatic improvements in naval forces. Jet-propelled aircraft, much faster and more powerful than earlier types, were introduced into the fleet, and new and larger aircraft carriers were built to accommodate them. The development of nuclear propulsion greatly expanded the horizons for submarine performance, significantly strengthening the submarine's already strong claim to prominence.

In the meantime, the surface combatant force was adjusting to a new role. The mighty battleships and cruisers were decommissioned rapidly in the years following World War II. No longer the centerpiece of the battle fleet, the surface combatant assumed primarily an escort role--that is, protecting other ships from attack by aircraft, submarines, or surface ships. This role was most closely associated with the traditional functions of destroyers; consequently, surface combatant construction in the postwar period has been devoted almost exclusively to ships that are derivatives of the destroyer type. 1/ These were built in large, medium, and small variants, designated destroyer leaders (DL), destroyers (DD), and destroyer escorts (DE), respectively. Those designations have since been changed to cruiser, destroyer, and frigate, but all are designed and equipped primarily to perform the escort The aircraft is the offensive strike arm of today's naval fleet; the aircraft carrier is the centerpiece of the U.S. battle group. Surface combatants protect and support the aircraft carriers.

EMERGING TECHNOLOGIES FOR SURFACE COMBATANTS

Recent technological developments hold out the prospect of substantially improved combat capabilities for surface combatants

^{1/} The only postwar new-construction ship of the cruiser type-in the sense of a World War II cruiser--was the USS Long Beach (CGN-9), the first nuclear-powered surface warship, commissioned in 1961.

--capabilities that not only will make them better escorts but may also restore some degree of independent strike capability to surface forces. Cruise missiles, autonomous aviation capability, and substantial technical improvements in radar, sonar, and command and control systems are among the factors combining synergistically to improve the combat potential of modern surface warships. Although these same factors are being employed by potential enemies to upgrade their naval forces, vigorous exploitation of new technological opportunities for surface combatants can be expected to produce a net gain in future U.S. naval capabilities.

Engagement Range and Firepower: Key Warship Capabilities

New technological developments that increase a warship's engagement range and firepower can have a particularly dramatic effect upon its combat capabilities. Engagement range and firepower, which are perhaps the most important among the many factors that collectively determine a warship's capabilities, are largely determined by the weapons and sensors mounted on a ship. $\underline{2}/$

Engagement range, the distance at which a ship can first bring enemy units under fire, has long been a key factor in naval warfare. It was, in fact, the basis for the dominance of big-gun ships in the battleship era. Not only did larger guns fire larger

^{2/} Endurance and resilience, primarily features of a ship's hull and machinery as opposed to combat system qualities, are two other important determinants of warship capability. Endurance and resilience are properly accorded great importance by U.S. warship designers. Endurance, which is a function both of the distance a ship can travel without refueling and of its ammunition and stores capacity, is clearly important to an oceangoing navy with worldwide deployments. Nuclear power provides the ultimate in endurance, but at substantial expense. Resilience, or the ability of a ship to survive the effects of combat, is also an important indicator of warship capability. Resilience is the product of many factors, such as system redundancy and shock hardening, as well as of a myriad of construction details that have been found by experience to make a ship resistant to damage. Collectively, all of these items make warship construction more costly, in general, than commercial ship construction.

shells, but they also had longer range. The battleship, therefore, with its larger guns, could destroy a cruiser before the cruiser could even close to engagement range; a cruiser could similarly outrange a destroyer. Aircraft, however, outranged all of the big guns and, as a consequence, the aircraft carrier became dominant at sea.

Deployment How New Weapons Increase Engagement Range. newly developed cruise missiles in the surface combatant force could yield significant increases in engagement range. cruise missile is basically a pilotless airplane that carries an explosive charge and utilizes a homing device to guide it to its target; hence it performs the function of an attacking airplane, although with far less tactical flexibility than a manned aircraft. Successful engagement of a target, of course, depends on much more than just the distance a missile will fly or a shell can be fired. A successful engagement requires the ability to detect a target initially, classify it as enemy or not, track it with sufficient accuracy for weapon launch and delivery, and control and coordinate the entire process. extent that surface combatants, either individually or in company with supporting units, can perform these additional targeting functions, cruise missiles can provide them with unprecedented new long-range attack capabilities against targets both at sea and ashore.

Firepower: Key to AAW and Antiship Missile Defense. Firepower is the level of fire a ship can maintain and, more importantly in many situations, the number of targets it can engage simultaneously. In the sailing-ship era, firepower was the chief determinant of warship strength--that is, the number of guns mounted on a ship provided a good index of its capability in battle. While today's combat environment is much more complex, the underlying principle has not changed. A ship that can sustain a high volume of fire against enemy forces enjoys an important advantage.

Of particular significance in the present combat environment is the ability to engage multiple targets simultaneously. Indeed, modern weapons and command and control capabilities could make it possible to orchestrate coordinated attacks so as to overwhelm a ship's defenses with multiple weapons all arriving nearly simultaneously. Observation of Soviet fleet exercises clearly points to this as a likely Soviet tactic. Such attacks become more difficult to accomplish successfully as the firepower and saturation threshold of the target ships (or aggregates

of ships) is raised. Consequently, firepower has particular relevance to naval anti-air warfare systems because of the threat posed by cruise missiles. Whether launched from an airplane, surface ship, or submarine, a cruise missile in flight is an AAW problem.

Deployment of Cruise Missiles: New Naval Strike Weapon

The cruise missile, a promising new offensive weapon for surface combatants, also poses a serious new threat to them. In a contest at sea, the key factor will probably be engagement range. The side that, through a combination of tactics, surveillance, and weapons capabilities, attacks first will enjoy an important advantage. High firepower, particularly in AAW, might, however, enable the opposing force to overcome the attacker's advantage.

Cruise missiles were first developed as tactical naval weapons in the Soviet Union about 20 years ago; the United States initiated its own development programs about 10 years later. 3/ The Soviets were motivated to develop cruise missiles as an alternative, and an antidote, to the overwhelming U.S. advantage in carrier-based tactical air power. Confident in its tactical air power advantage, the United States was relatively late in taking up cruise missile development but has placed increasing emphasis on cruise missile systems in the past decade. Among the various types that have been developed, two--the Harpoon (AGM/RGM-84) and the Tomahawk (BGM-109)--are of particular interest for surface combatant applications. 4/

^{3/} The United States had developed operational cruise missiles for strategic missions at an earlier date. Regulus cruise missiles were deployed in submarines before Polaris ballistic missiles were developed.

^{4/} In addition to the United States and the Soviet Union, six other nations, all U.S. allies, have developed cruise missile designs of their own, and cruise missiles are now employed by navies all over the world. The Soviets have provided cruise missiles to many of their client states; the Soviet (SS-N-2) Styx missile is now employed in the navies of 21 different nations. The U.S. Harpoon will be employed by at least nine nations.

One of the chief attractions of the cruise missile is its compatibility with a variety of launch vehicles. 5/ The Harpoon, although initially designed as an air-launched cruise missile, is now launched from surface ships and submarines as well. For launches from surface ships, it can utilize existing Tartar, Terrier, Standard, or ASROC (antisubmarine rocket) missile launchers, thus saving expensive backfit costs. Alternatively, it can be launched from relatively simple "box" launchers fixed to a ship's deck. For launches from submarines, the missile must be placed in a buoyant launch capsule that can be fitted into standard submarine torpedo tubes.

<u>Harpoon</u>. Developed and deployed as an antiship weapon, Harpoon uses inertial guidance during its cruise phase and an active radar seeker for terminal homing. <u>6</u>/ It has a range of 120 nautical miles when launched from aircraft and about 60 nautical miles when launched from surface ships or submarines.

Tomahawk. A somewhat newer and more capable missile than Harpoon, Tomahawk also can be launched from aircraft, surface ships, or submarines, and is slated to have a ground-launched version as well. Tomahawk will be deployed in a long-range (1,550 nautical miles) land-attack version called the Tactical Land Attack Missile (TLAM) and a shorter-range (280 nautical miles) antiship version called the Tactical Antiship Missile (TASM). Capable of carrying either a nuclear or a conventional warhead,

^{5/} U.S. cruise missiles (and missiles developed by U.S. allies) tend to be much smaller than Soviet versions. Although larger cruise missiles can obviously carry larger warheads, the smaller size of U.S. missiles allows more of them to be carried on a launch vehicle and permits much more flexibility in selecting and outfitting launch vehicles.

^{6/} Terminal homing devices, which enable a missile to "see" and home on its target, can take a variety of forms. These include active radar (a small radar set carried in the missile), a missile-borne television camera, or a seeker that homes on infrared or radio frequency energy eminating from the target. Each of these has its advantages and disadvantages, but active radar is the most common type of terminal guidance ("seeker") for antiship cruise missiles.

the land-attack version will use terrain comparison. (TERCOM) guidance to navigate to its target.

The TERCOM system uses a radar altimeter to scan the terrain below at predetermined intervals during the missile's The system compares the topography seen from the missile to a reference ground profile programmed into its memory. The movement required to effect a match yields coordinates that are used to update the missile's position reference. such a "fix" can be taken just before impact, very precise guidance is obtained. The antiship version of Tomahawk uses a modified version of the Harpoon active radar seeker for terminal homing. Tomahawk has been designed to have a very small radar cross-section and a small infrared signature that should make it very difficult to destroy despite its subsonic speed. Initial operational capability (IOC) for the Tomahawk is scheduled in fiscal year 1982 for the submarine fleet and in fiscal year 1983 for the surface combatant force.

Over-the-Horizon Surveillance and Targeting: Essential for Cruise Missiles and Tactical Success at Sea

Although one of the most important benefits of cruise missiles is the increase in engagement range they provide, this benefit is not necessarily realized simply by equipping a ship with cruise missile launchers. Because the curvature of the earth limits a ship from detecting other ships, either visually or by radar, at distances beyond 25 to 30 nautical miles, a cruisemissile-equipped ship may be unable to exploit the full range of a missile such as Harpoon (to say nothing of the 280-nautical-mile range of Tomahawk). This over-the-horizon (OTH) detection and targeting problem is the most important issue in realizing the full potential of the cruise missile weapon at sea. To obtain over-the-horizon targeting information, a ship must rely on data from other sources that can detect and target distant enemy These can include the ship's own aircraft, such as LAMPS (Light Airborne Multipurpose System) helicopters; other ship-based or land-based aircraft in the area; or a variety of other external sources such as satellites or intelligence. 7/

Aircraft are particularly attractive for the OTH surveillance and targeting role because their speed and elevation enable them to search very large areas in a short time. LAMPS has

The Navy intends to use OTH targeting information from any one or several of these sources and is experimenting with ways of efficiently correlating and displaying the information available for antisurface warfare (ASuW). 8/

The over-the-horizon targeting problem for cruise missiles is a specific case of the broader and historically long-standing problem of obtaining information on the location and movements of enemy forces at sea. Superiority over the enemy in this area can yield decisive benefits; conversely, enemy superiority, even if in this area alone, can have disastrous effects. No matter how effective naval weapons may be, they cannot be employed without knowledge of the enemy's location; likewise, no matter how crude the enemy's weapons may be, he can win if he attacks first.

The over-the-horizon targeting problem is, therefore, both a manifestation and a subset of a very fundamental problem in naval warfare. It is likely that the side that best solves the targeting problem for cruise missiles will not only realize an advantage in their employment, but will also enjoy a more basic advantage in tactical information at sea. The Soviets seem to be well aware of this and have developed a large, highly centralized system to

the advantage of being indigenous to the ship's combat system, although other aircraft, such as land-based P-3Cs, may carry better sensors. Radar satellites, when and if deployed, could surveil the oceans more rapidly still, but would provide massive amounts of data to be correlated and would probably be less able than aircraft to provide classification and other essential information to the missile ship.

^{8/} Under the OUTLAW SHARK program, the Navy has developed a device, AN/USQ-81(V), to collect and display targeting data. Capabilities developed under this program will be incorporated in the Common Weapons Control System (CWCS) that is being developed for the Tomahawk. The first prototype CWCS is scheduled to go to sea in late fiscal year 1981, and is expected to be ready for fleet introduction on a schedule consistent with the fiscal year 1983 Tomahawk IOC date for surface combatants. Testimony of Honorable David E. Mann, Assistant Secretary of the Navy for Research, Engineering, and Systems, in Department of Defense Appropriations, Fiscal Year 1981, Hearings before the Subcommittee on Defense, Senate Committee on Appropriations, 96:2 (1980), Part 4, pp. 127-29.

collect information on U.S. forces and to direct and coordinate attacks against them. 9/ The United States enjoys an advantage in some aspects of this contest, particularly its superiority in electronics and data-processing technology and in carrier-based tactical air power. It is not clear, however, that U.S. efforts in surveillance and targeting are as well focused or as effective as Soviet efforts in this area.

Helicopters: Over-the-Horizon Surveillance Today. Perhaps the most significant development in extending surface combatant surveillance and targeting capability in the past decade has been the rapid proliferation of helicopter landing and support facilities on naval ships. Helicopters have now become a common feature on most new surface combatant designs, even on relatively small frigates. This trend has been particularly evident in the United States, and almost all of the recently designed surface combatants--CGN-38-class cruisers, DD-963 and DD-993-class destroyers, FFG-7-class frigates, and CG-47-class cruisers--have been equipped with helicopter support facilities. This movement toward an aircraft-support capability has been motivated largely by a need to expand the reach of the surface warship--that is, to expand the area over which it can detect and prosecute targets.

Vertical/Short Takeoff and Landing (V/STOL) Aircraft: Over-the-Horizon Surveillance for Tomorrow? The currently emerging V/STOL technology is particularly promising for over-thehorizon surveillance and attack. The helicopters now widely used by modern surface combatants are the best aircraft presently available for operations from small, noncarrier platforms. As a general rule, however, helicopters compare unfavorably with fixed-wing aircraft in terms of speed, range, and endurance. V/STOL technology offers the possibility of obtaining flight performance more nearly comparable to that of fixed-wing aircraft with an airplane that can land and take off from small platforms. Examples of V/STOL airplanes for the fleet air coverage mission that offer much better speed and endurance than helicopters are the Bell XV-15 tilt-rotor aircraft and the Grumman turbofan V/STOL-design 698. Aircraft of this type, if and when they become available, could provide substantially improved performance, as shown in Table 2, over that available from helicopters. At

^{9/} For a discussion of the Soviet approach, see William J. Ruhe, "1980 Soviet Strategy for War at Sea," <u>Defense Electronics</u> (July 1980), pp. 43-51.

TABLE 2. COMPARISON OF HELICOPTER AND V/STOL CAPABILITIES

	Helicopter (UTTAS/LAMPS III)	V/STOL (Grumman 698)	
Performance			
Maximum speed (knots)	160	500	
Ceiling (thousand feet)	19	50	
Radius (nautical miles) Time on station at 100	160	700	
nautical miles (hours)	2.0	3.6	
Systems Compatibility Airborne early warning			
radar installation	No	Yes	
Armament	Fair	Better	
Ship Compatibility			
Deck area requirement	Medium	Smaller	
Folding complexity	Complex	Simpler	
Gust susceptibility	High	Lower	
Development Status	Demonstrated	Undemonstrated	

SOURCES: Jane's All the World's Aircraft, 1980-81; Robert W. Kress, "Surface Combatant Fleet Offensive/Defensive Enhancement by High Performance Turbofan VTOL Aircraft" (paper prepared for delivery at the August 1980 AIAA Aircraft Systems Meeting; processed).

the very least, they could provide the fleet with a means of more fully utilizing the long-range weapons now becoming available. $\underline{10}/$

^{10/} Moreover, V/STOL aircraft can provide naval forces with a more widely distributed and more flexibly based aviation capability than is possible with large aircraft carriers alone. Some knowledgeable observers believe that such

Towed Arrays: A New Kind of Sonar That May Produce the Longer-Range Submarine Kills Needed Against Today's Threat

The long-range weapons now available to submarines have made it essential for ASW escorts to be able to engage attacking submarines at much longer ranges than was previously the case.

Today's submarines are armed with long-range cruise missiles and modern, wire-guided torpedoes whose accoustic homing devices permit them to be fired from ranges as great as 10 nautical miles or more, with reasonable chance of success. This is considerably beyond the engagement range of even relatively recent ASW ships that use hull-mounted active sonar and hull-borne ASW weapons such as ASROC. 11/

distributed basing is essential for naval forces in the current tactical environment. See, for example, Admiral Stansfield Turner, USN (Ret.), "Thinking About the Future of the Navy," U.S. Naval Institute Proceedings (August 1980), pp. 66-69. The Defense Science Board Task Force on Surface Ship Vulnerability took the view in a recent study that the Navy should reduce dependence on "citadels" and distribute modern offensive and defensive capabilities among ships other than aircraft carriers and CG-47s. For an unclassified version of that report, see Military Posture and H.R. 6495, Hearings before the Subcommittee on Seapower and Strategic and Critical Materials, House Committee on Armed Services, 96:2 (February and March 1980), Part 4, Book 1, pp. 1112-23. Another means of distributing aviation capability that could provide excellent flexibility is the ARAPAHO concept. ARAPAHO is a set of modular, containerized aircraft support facilities together with modular living facilities that can be rapidly erected on any of a wide variety of merchant ships. For a recent discussion of the ARAPAHO program, see James J. Mulquin, "Navy Completes First Flight Tests on ARAPAHO," <u>Seapower</u> (November 1980), p. 31; and James J. Mulquin, "Wartime Commercial Ship Protection with ARAPAHO," British Aerospace Inc. Quarterly (November 1980), p. 16.

11/ Active sonar systems put a pulse of accoustic energy (a "ping") into the water and listen for echoes off the submarine hull. Passive sonar systems listen for noises emanating from the submarine. ASROC uses a rocket to propel an ASW torpedo to the immediate vicinity of a submarine contact.

The Navy has undertaken several programs to improve the ASW engagement range of surface combatants. One such initiative is the development of tactical towed-array sonar systems (TACTAS), which are passive sonar systems that can provide much longer-range detection of submarines than is normally possible with active sonars. 12/ Another such development is the LAMPS helicopter. which is used to investigate and prosecute ASW contacts detected by a ship's sonar systems. (This function is in addition to the over-the-horizon surveillance and targeting function discussed above.) Towed-array sonar systems consist of a long linear array of hydrophones towed well behind a ship by a wire, together with sophisticated electronic equipment aboard the ship for analyzing the signal from the hydrophones. They offer the surface ship, for the first time, the possibility of achieving parity with the submarine in passive listening capability. The long-range detections made possible by towed-array sonar systems will be of limited value, however, without a means of localizing and attacking enemy submarines -- the function performed by LAMPS. LAMPS and/ or other ASW aircraft in the vicinity of the towed-array ship can extend the surface combatant's ASW engagement range to something more commensurate with that of modern submarine weapons. The Navy is also developing an integrated ASW network that will correlate and transmit information derived from various sources -- intelligence, satellites, SOSUS, SURTASS, and tactical aircraft -- to forces at sea. 13/ These developments establish some basis for optimism that the Navy will achieve the means to engage submarines successfully beyond the immediate proximity of a circular screen.

Anti-Air Warfare: Increased Threat, Increased Capabilities

Aircraft and cruise missiles pose a major threat to surface combatants, and, in order to survive in the modern combat

^{12/} Two types of tactical towed-array sonar systems are currently under development by the Navy. These are the AN/SQR-18 for the FF-1052-class frigates and the AN/SQR-19 currently scheduled to be deployed aboard the DD-963 and CG-47-class ships.

^{13/} SOSUS (Sound Surveillance System) is a system of large fixed sea-bottom hydrophone arrays that passively listen for sounds generated by submarines. SURTASS (Surveillance Towed-Array Sonar System) is a group of towed arrays deployed on ships (T-AGOS) that will supplement SOSUS and allow increased surveillance in areas of particular interest.